MERCURY

By William E. Brooks

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In 2002, the United States continued to rely upon in-plant recycled mercury from and for use by the chlorine-caustic soda industry, the largest domestic end use for mercury, and consumed some mercury imported from Australia and Chile. Even though there are mercury resources in the United States, the last mine to produce mercury as its primary commodity, the McDermitt Mine, in Nevada, closed in 1992. Mercury is also obtained as a byproduct of domestic gold mining; however, production data are not available. The toxic effects of mercury on human health are well known; in 1971, the U.S. Environmental Protection Agency (EPA) indicated that mercury was a hazardous air pollutant. This, combined with increasing environmental concerns about mercury releases and research into alternative methods for chlorine-caustic soda production, has resulted in declining demand for the metal. By yearend 2002, the United States had 4,436 metric tons (t) of mercury stockpiled by the Defense Logistics Agency (DLA).

Legislation and Government Programs

Because mercury is a toxic metal that is widely used and known to adversely affect human health, it is studied and regulated by environmental and health agencies worldwide (Porcella and others, 1995). The nervous system, brain, kidneys, and fetal development may be adversely affected by exposure to high levels of mercury, and a link between autism in children and mercury in the environment seems likely (Hightower, 2001§[1]). However, there are insufficient data to indicate that mercury is carcinogenic in humans. In the 1960s, the effects of mercury releases on human health in Japan or "Minamata disease" caused headlines worldwide (Bunce and Hunt, 2003§). The United Nations Environmental Programme (2002§) completed a Global Mercury Assessment in which issues concerning global persistence of mercury in the environment, health effects in less developed regions, the global fishing industry, and sources of mercury releases were examined.

The EPA has set a limit of 2 parts per billion (ppb) mercury in drinking water; the U.S. Food and Drug Administration has set a maximum of 1 part per million (ppm) of methylmercury in seafood; and the U.S. Occupational Safety and Health Administration has set a limit of 0.1 milligram per cubic meter in workplace air (Agency for Toxic Substances and Disease Registry, 2003b§). The American Medical Association has resolved that the mercury content of foods, especially fish, be labeled and that physicians educate their patients as to the potential dangers of mercury ingestion (McCaffree, 2003§).

Major sources of mercury pollution, in descending order, include coal-fired powerplants and industrial boilers, municipal and medical waste disposal, recycling and hazardous waste disposal, chlorine-caustic soda production, and volcanic activity (Clean Air Network, 2000§; Mercury Instruments, 2003§). Emissions of mercury by coal-fired powerplants and other industrial sources pose an increasing health danger to children, and legislation has been proposed that would cut emissions by 2010 (Fialka, 2003).

Research by the U.S. Geological Survey (USGS) has contributed to understanding the health impacts of coal combustion (Finkelman, 2000), the abundance and distribution of mercury in domestic coal (Tewalt and others, 2001), and mercury content of coal on a global scale (Finkelman and others, 2001). The USGS collaborates with other Federal and State agencies, universities, and tribal nations in the National Atmospheric Mercury Deposition Network, a continent-wide program to monitor mercury deposition through a network of standardized monitoring sites (Nilles, 2000, 2003§). Samples are collected by the USGS, for example, at sites that include Culpeper and Shenandoah National Park, VA; mercury content is determined by the EPA (Kolker, 2003). USGS scientists also have examined glacial ice cores as part of studies focused on the history of global mercury contamination (Krabbenhoft and Schuster, 2002).

The USGS and the EPA, in collaboration with academic, tribal, and research organizations as well as other government agencies participate in periodic USGS/EPA Mercury Roundtable teleconferences (Krabbenhoft and Herrmann, 2000§). Recent conference topics included the effects of methylmercury on fish, sources of mercury in the Everglades, the legacy of mercury mining in California, and methods to reduce mercury in coal.

The USGS Toxic Substances Hydrology Program and the Mine Drainage Interest Group concern the characterization of mercury contamination, bioaccumulation, and environmental problems related to mining across the country (Suchanek and Di Pasquale, 2003§). USGS study sites in Virginia include closed pyrite mines near Contrary Creek and Prince William Forest Park (Cravotta and others, 2003§).

Studies by the EPA and the National Wildlife Federation show that rain falling in the Midwest, specifically Chicago's North Shore, may contain up to 32 times the amount of mercury that is considered safe. This is of concern because of the bioaccumulation of mercury in fish (Pierre, 2003; McCann, 1999§) that is related to mercury emitted by coal-fired powerplants (Pennsylvania Department of Environmental Protection, 2003§). Warnings are posted about mercury content of fish in some parts of Florida (Mercury Roundtable, oral commun., June 17, 2003), and in 1989, a consumption advisory for mercury and organic chemicals for fish caught in

[1]References that include a section mark (§) are found in the Internet References Cited section.

the Anacostia and Potomac Rivers was issued by the District of Columbia (Agency for Toxic Substances and Disease Registry, 2003a§). Proposed Clear Skies legislation in Congress would require powerplants to reduce overall pollution levels by 70% by 2018 (Planin, 2003; U.S. Environmental Protection Agency, 2000§). However, the Clean Air Planning Act, which is an alternative bill, would cut powerplant emissions of mercury, sulfur dioxide, and other pollutants by larger amounts by 2012 (Gugliota and Planin, 2003).

Mercury emission guidelines for electric steam generating units are provided by the EPA (U.S. Environmental Protection Agency, 2000) and for hospital and medical waste incinerators (U.S. Environmental Protection Agency, 2003a§).

Approximately 6 million mercury thermometers, each containing 0.7 gram of mercury, recently were sold in the United States during a single year (Goldstein, 2000). Widespread use of such thermometers presents a health risk if broken in the user's home or if the thermometers are dumped in landfills or incinerated. A number of environmental and health organizations petitioned Congress to limit the use of mercury fever thermometers and improve the collection and management of mercury (Lyon, 2001§). Subsequently, sale of such thermometers was banned, and use of nonmercury thermometers has been encouraged (U.S. Environmental Protection Agency, 2003b§). Mercury use in paints (fungicide) and batteries also has been discontinued (Mercury Policy Project, 2002§). Dental amalgam also uses mercury and it is unknown how much mercury is released into the environment by removal or replacement of mercury amalgam fillings (District of Columbia Dental Society, 2003§); however, approximately 12,000 kg of amalgam was sold in the United States in 2001 (Maine Department of Environmental Protection, 2003§). The use of mercury batteries, which were once widely used in watches, cameras, and hearing aids, has declined because of new technologies and concern for the environment (Battery-Index, 2003§).

Mercury is a common byproduct of lode gold mining worldwide. In 1998, an estimated 650 kg of mercury were released into the atmosphere as the result of precious metal smelting at a mine in Nevada (Rogers, 2000§). However, mine owners in Nevada have voluntarily begun to reduce mercury emissions by 50% during a 3-year period (Gold, 2002). Mercury also is used in artisanal placer gold mining worldwide to amalgamate gold flakes; mercury releases may take place during mining and amalgam treatment in some developing countries. The USGS has led mercury and mining studies in Suriname (Gray, Crock, and Lasorsa, 2002), the Philippines (Gray and others, 2003), California (Alpers, 2002§), and Nevada (Gray, Labson, Weaver, and Krabbenhoft, 2002). Use of mercury in Latin American mining operations was addressed at a conference in Vienna, Austria, in 1997 (Veiga, 1997§), and a mercury spill related to gold mining in Peru in 2000 gained worldwide attention (Drillbits and Tailings, 2000§; Griffin, 2000§). Volcanic activity also contributes mercury to the environment; USGS research shows that mercury is lost from the forest floor during forest fires (Woodruff and Cannon, 2001; Woodruff and others, 2001).

At yearend 2002, the DLA had an inventory of 4,436 t of mercury at several sites in the United States. Until 1994, this mercury was available for sale; however, in response to environmental concerns, mercury sales have been suspended. Management alternatives for the mercury in the DLA include leaving the mercury at scattered sites, consolidation at one site, and sale of the inventory (Defense National Stockpile Center, 2002). Environmental, transportation, and geologic hazard issues have been carefully examined, and a series of public comment meetings have been held at locations that may be affected. The DLA indicated that a decision on disposition of the mercury would be reached in early 2004.

Chlorine production is a major end use of mercury. Chlorine is an important industrial chemical that is used in the pulp and paper industry, for water treatment, defense against biological attacks, antibiotics, microprocessors and computer housings, flak jackets, helmets, and bullet-proof glass (Chlorine Institute, 2003§). Losses of mercury in the chlorine production process were 200 grams of mercury per metric ton of chlorine output in the 1960s, but only 0.2 gram of mercury per metric ton of chlorine produced is lost today (Bunce and Hunt, 2003§). Mercury releases in India total 60 to 70 metric tons per year (t/yr) of mercury as a result of chlorine production (Bahuguna, 2003§), and the obligatory dismantling of 47 chlorine plants in Europe by 2007 will result in 15,000 t of mercury that must be managed (Faversham House Group, 2003§). Closure of a chlorine plant in Maine resulted in approximately 100 t of mercury that must be reused, stockpiled, or sold (HoltraChem Manufacturing, 2000§). New technologies for chlorine production include the diaphragm and membrane cells; however, the disposal or storage of mercury that will ultimately result from dismantling plants that use mercury cell technology for chlorine production is a serious international and environmental concern (Olin Chlor Alkali Products, 2003§).

Production

There has been no primary domestic production of mercury since closure of the McDermitt Mine, sometimes referred to as the Cordero Mine, in Nevada in 1992 (O'Driscoll, 2002§); now the mine is included on a list of EPA superfund sites (ToxicAlert, 2003§). Although there is no primary production of mercury in the United States, byproduct mercury is produced as a part of some domestic gold mining and smelting operations (Rogers, 2000§). In addition, secondary mercury is recovered by U.S. recyclers from domestic and imported scrap.

There are mercury occurrences in California (Dickson and Tunell, 1968; Linn, 1968), Idaho (Dickson and Tunell, 1968), Nevada (Dickson and Tunell, 1968; Fisk, 1968; Bateman, 1988), and Texas (Bauer, 2000). The geoenvironmental impact of arsenic and mercury in Alaska and California is an ongoing USGS research project (U.S. Geological Survey, 2003§), and the EPA lists mercury occurrences in Alaska, Arkansas, and Oregon (U.S. Environmental Protection Agency, 1973).

Mercury used in car switches (McCann, 2002; Natural Resources Council of Maine, 2003§) and lamps (Abernathy, 2003) is of environmental concern during scrapping or waste treatment; however, mercury can be recovered for recycling from batteries, dental amalgam, lamps, mercury waste, switches, and thermostats. Producers of recycled mercury include Bethlehem Apparatus Co. (2003§) in Pennsylvania, D.F. Goldsmith Chemical and Metal Corp. (2003§) in Illinois, and Mercury Waste Solutions (2003§) in Minnesota.

A list of more than 50 individuals and companies that recycle mercury is available (Mercury Recyclers, 2002§). Mercury, which may occur with lode gold occurrences, is also obtained from gold processing operations and is classified as byproduct mercury (B.J. Lawrence, President, Bethlehem Apparatus Co., written commun., 2003). The largest amount of byproduct mercury comes from Nevada, however, there are no data on the amount of mercury produced.

Consumption

The chief end use for mercury in the United States is in chlorine-caustic soda production, and mercury was recycled in-plant by the chlorine-caustic soda industry in 2002. A limited amount of mercury was imported from Australia (107 t) and Chile (75 t) during 2002. The industry has set a goal of reducing mercury use by 50% before 2005, in comparison with the base years of 1990-5. Domestic mercury consumption is estimated to be 33% to 50% for chlorine manufacture, 33% to 50% for electronics, and the balance for other uses such as dental applications, lamps, switches, and thermostats.

World Review

For the period 1990-2000, world mercury production averaged 2,200 t/yr. Most countries do not report production data because of environmental and health concerns; therefore, production estimates have a high degree of uncertainty. Algeria, China, Kyrgyzstan, and Spain are the apparent leaders in world production of mercury; production for Algeria is estimated for 2002 to be 800 t. Minas de Almaden (Spain) can produce 50,000 flasks per year[2], and new production has been reported from Spain (Metal Bulletin, 2003). Both Algerian and Spanish producers are negotiating prices in the range of $175 to $195 per flask (Metal-Pages, 2003b). Demand is strong in China and the Asian market; uses include batteries, lamps, and thermometers. Chinese mercury production is reported to have risen by 6.5% (164 t) in 2002 (Metal-Pages, 2003a). Becton, Dickinson and Co. indicated that it will stop production of glass mercury thermometers at its plant in Brazil and will stop purchasing thermometers from China (Goldstein, 2000). Environmental concern caused closure of a thermometer plant in India and now that waste material will be transported to the United States for recycling (Marley, 2003).

Outlook

Mercury demand and production will continue to be adversely affected by international environmental and human health concerns. Technological advances and changes in the chlorine-caustic soda industry, the primary end use for mercury, will result in a decline in mercury use as alternative production systems are used and mercury cell plants are gradually closed in Europe, the United States, and India—thereby releasing large amounts of mercury for storage or sale. Voluntary reduction of mercury emissions by copper, gold, and zinc mining companies, stricter controls of mercury use in artisanal gold mining, and careful monitoring of mercury releases by the chlorine-caustic soda industry will lessen releases to the environment and generally contribute to a decline in mercury prices. Recycled mercury obtained from dismantling mercury cell chlorine-caustic soda plants, byproduct mercury from gold mining, and mercury contained in the National Defense Stockpile is more than adequate to meet domestic needs.

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TABLE 1
SALIENT MERCURY STATISTICS[1]

(Metric tons, unless otherwise specified)

	1998	1999	2000	2001	2002
United States:					
Secondary production, industrial	NA	NA	NA	NA	NA
Imports for consumption	128	62	103	100	209
Exports	63	181	182	108	201
Industry stocks, yearend[2]	NA	NA	NA	NA	NA
Industrial consumption	NA	NA	NA	NA	NA
Price, average per flask, free market[3]	140	140	140 r	140 r	140
World, mine production	1,580	1,310	1,350 r	1,490 r	1,800

rRevised. NA Not available.

[1]Data are rounded to no more than three significant digits, except prices.

[2]Stocks at consumers and dealers not available. Mine stocks withheld to avoid disclosing company proprietary data.

[3]Source: Platts Metals Week.

TABLE 2
U.S. IMPORTS AND EXPORTS OF MERCURY, BY COUNTRY1

(Gross weight, unless otherwise specified)

Country	2001 Quantity (metric tons)	2001 Value (thousands)	2002 Quantity (metric tons)	2002 Value (thousands)
Imports:				
Australia	--	--	107	$187
Canada	8	$11	11	14
Chile	41	27	75	53
Germany	22	730	15	614
Italy	(2)	6	--	--
Peru	29	34	--	--
Spain	--	--	1	12
United Kingdom	(2)	8	(2)	9
Total	100	816	209	889
Exports:				
Brazil	4	139	2	23
Canada	3	20	4	26
France	3	43	8	124
Germany	5	30	21	54
India	18	53	21	68
Japan	3	72	2	59
Korea, Republic of	2	32	7	34
Malaysia	2	17	--	--
Mexico	12	87	33	237
Netherlands	17	43	73	281
Peru	4	54	--	--
Singapore	1	17	18	62
Spain	18	57	--	--
United Kingdom	4	63	--	--
Other	12	124	12	77
Total	108	851	201	1,045

-- Zero.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Less than 1/2 unit.

Source: U.S. Census Bureau.

TABLE 3
MERCURY: WORLD MINE PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country	1998	1999	2000	2001	2002
Algeria	224	240	216	320 [r]	800 [e]
China[e]	230	200	200	190 [r]	250
Finland	54	40	76 [r]	71 [r]	70
Kyrgyzstan	250	300	257	300	250
Mexico[e]	15	15	15	15	15
Russia[e]	50	50	50	50	50
Slovakia	20 [e]	--	--	--	--
Slovenia	5 [e]	--	--	--	--
Spain	675	433	500	500	300
Tajikistan[e]	35	35	40	40	20
Ukraine	20 [e]	NA	NA	-- [r]	NA
United States[3]	NA	NA	NA	NA	NA
Total	1,580	1,310	1,350 [r]	1,490 [r]	1,800

[e]Estimated. [r]Revised. NA Not available. -- Zero.

[1]World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2]Table includes data available through April 29, 2003.

[3]Data on mercury produced as a byproduct of gold mining are not available.